Small-area variation in mortality in the city of Oulu, Finland, during the period 1978–1995

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Abstract

The aim of the present work was to explore small-area differences in mortality from all causes among males and females within the city of Oulu during the period 1978–1995 and to identify areas where mortality has been persistently high or low. Analyses carried out using Geographical Information System techniques with geo-referenced mortality data produced at a resolution of $1 \times 1$ km showed significant regional variations in mortality within the city. The differences were wide enough to suggest variations of several years in longevity, and were probably indicative of marked variations in the incidences of diseases. Observed mortality differences may reflect the influence of the rapidly changing urban structure and consequent health effects based on selection, lifestyles, work exposures and deprivation. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

One purpose of mapping the geographical distribution of mortality is to identify areas having unusually high or low mortality rates (Owen et al., 1996). Mortality has been studied in large geographical areas, e.g. regions in England and Wales (Britton, 1980) and counties in the USA (Mason and McKay, 1973). Regional studies on mortality and disease rates in Finland have previously used administrative regions such as provinces (Koskinen, 1994; Karvonen et al., 1997) or local government districts (Näyhä, 1986, 1987). Later, the development of high-quality geo-referenced data and the Geographical Information System (GIS) have made it possible to investigate variations in disease rates in Finland in still greater detail. Examples include studies on geographical variations in the incidence of childhood diabetes mellitus based on $10 \times 10$ km grid cells (Ranta et al., 2000) and (Rytkönen et al., 1999). No previous study in this country has ever reported mortality at this level of geographical precision. We therefore focused on mortality in the city of Oulu, northern Finland, during the period 1978–1995, using geo-referenced data at a resolution of $1 \times 1$ km. A mapping of mortality in such detail would offer a rational basis for targeting health interventions, allocating resources and generating causal hypothesis (Cuzick and Elliott, 1992).

The hierarchical settlement structure in Finland has undergone marked changes during the last few decades. An accelerated polarization process, especially in the 1990s, has concentrated the population in four main growth areas, of which the Oulu region is the northern-most one, with the city of Oulu as its industrial hub (Naukkarinen et al., 1999). Mainly due to in-migration from nearby areas and the south, population trends in Oulu have been favourable over this period. This has been accompanied by a decline in mortality since the 1970s, mainly due to a decrease of cardiovascular diseases (Näyhä and Hassi, 1999). During the study period, life expectancy in Oulu increased from 68.4 to 72.5 years (Näyhä and Hassi, 1999).
73.0 years in males and 77.5 to 80.3 years in females — increase was greater than those seen in the whole of the country. The underlying reasons for these positive trends are not known, but health-based selection associated with in-migration may play a role. We similarly assumed that the rapidly changing urban structure may have introduced changes in the distribution of mortality within the city. Mortality was therefore correlated with population density — a measure for the degree of urbanization and we also looked for areas where mortality has been persistently high or low.

2. Material and methods

Every resident of Finland has a unique personal identification number which can be used for linking records between various national databases on an individual basis. This also allows every individual to be located by means of the map coordinates of his or her place of residence and postal address. Deaths from all causes that occurred in the city of Oulu during the period 1978–1995 were aggregated into $1 \times 1$ km grid cells based on the place of residence at the time of death. For reasons of confidentiality, only cells having at least 30 deaths were included in the analysis. Mortality data were available for 56 of the 240 one square kilometre cells making up the land area of Oulu, the rest of the cells being located in sparsely populated districts, mainly forest and fields, or otherwise having only small numbers of deaths. Mid-year populations aggregated in the corresponding way and classified according to sex and 5-year age bands were drawn from the National Population Register.

A standardized mortality ratio (SMR) was calculated for each grid cell using an indirect age adjustment (Armitage, 1971; Hernberg, 1992) in which age-specific mortality by sex in the city of Oulu in the respective periods was used as the standard. The 95% confidence interval for the SMR was calculated.

Data conversion, linking, manipulation and outputs were done using the ArcInfo GIS software in Unix environment. The SAS statistical software was also used together with GIS for data manipulation procedures and basic statistical operations.

3. The city of Oulu

There were approximately 110,000 people living within the administrative boundaries of the city of Oulu in 1995, with 74% of the active population earning their livelihood in the tertiary sector and 24% in the manufacturing industries. During the 1980s and 1990s a marked shift had occurred from manufacturing to economic activities of post-industrial type, mainly advanced technology, and this was reflected in a change in age distribution, so that the proportion of people of working age now exceeds that of the passive segment. Continued in-migration is expected to make the population structure even more favourable in the future, although the proportion of older people is also increasing rapidly, as it is in most Western European cities.

4. Results

There were approximately three-fold differences in mortality to be seen within the city of Oulu during the period 1978–1995. Male mortality reached twice the average figure in the west-central and north-west parts of the city and was 30–40% below the average in the east (Fig. 1) while the pattern of female mortality was very similar, with high figures in the central and north-western parts of the city and low figures in the eastern and southern parts (Fig. 2). Out of the total of 56 cells considered, 12 SMRs for males and six for females differed significantly from the average, while not more than three in each case could have been expected by chance alone.

Fig. 1. Geographical variation in all-cause mortality among men in the city of Oulu, 1978–1995. * differs significantly from 100. (Data: Statistics Finland, Map: University of Oulu, Department of Geography).
The association of mortality with population density (divided into quartiles of population) was slightly U-shaped, with different trends for the males and females (Table 1). Among the males mortality was 8% higher than average in the cells that had the highest population density and 5% lower in those with the second lowest density, while in the case of the females the trend was the opposite, mortality being highest in the cells with the lowest population density and lowest in those having the second lowest density.

To identify cells with persistently high or low mortality, the SMRs in the two extreme periods (1978–1980 and 1991–1995) were classified to form quartiles (i.e. 25% of the cells were assigned to each class). The cells belonging to the first quartile in both periods were termed low mortality areas and those belonging to the last quartile in both periods high mortality areas. The low mortality areas for males were those that had SMRs < 65.4 and < 75.8 in 1978–1980 and 1991–1995, respectively, and the high mortality areas those having SMRs of ≥ 120.6 and ≥ 117.1, respectively. For the females, the low mortality areas corresponded to SMRs of < 77.9 and < 89.9 in the periods concerned and the high mortality areas to SMRs of ≥ 114.0 and ≥ 126.3, respectively.

In some areas mortality from all causes was persistently high or low. Male mortality was persistently high in some cells located in the west-central and north-west districts, while areas having persistently low mortality were more sporadically distributed (Fig. 3), the picture being similar in kind for the females (Fig. 4).

5. Discussion

Our analyses showed significant regional variations in mortality within the city of Oulu. The differences were wide enough to suggest variations of several years in longevity, and were probably indicative of marked variations in the incidences of diseases or violent events (Na¨yha¨and Hassi, 1999). A recent report shows an accumulation of social and material deprivation in certain areas of the city of Oulu, and this trend has become stronger in recent years (La¨msa¨, 1998). The areas of high mortality largely correspond to the deprived areas observed in the above report, and it is therefore likely that the high mortality in the deprived areas is partly linked with adverse lifestyles such as smoking and excessive alcohol consumption typical for the disadvantaged segment of population (Koskinen, 1994). Factors contributing to regional mortality differences within the city might include the slower diffusion of healthy lifestyles from higher to lower social classes and lesser efficacy of preventive efforts among the disadvantaged population during the last 20 years.

Table 1
All-cause mortality and population density in the city of Oulu, 1978–1995. The SMRs are averaged over the cells in each quartile, using cell-specific populations in 1985 as weights.

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Inhabitants/km²</th>
<th>Population</th>
<th>No. of grid cells</th>
<th>SMR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Males</td>
<td>Females</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>1–691</td>
<td>20,044</td>
<td>29</td>
<td>98</td>
</tr>
<tr>
<td>II</td>
<td>692–1565</td>
<td>20,350</td>
<td>13</td>
<td>99</td>
</tr>
<tr>
<td>III</td>
<td>1566–2248</td>
<td>20,234</td>
<td>9</td>
<td>95</td>
</tr>
<tr>
<td>IV</td>
<td>2249–4017</td>
<td>20,089</td>
<td>5</td>
<td>108</td>
</tr>
</tbody>
</table>
Bearing in mind the high quality of personal records and the practically complete coverage of the register of deaths in this country, we believe that our results cannot be severely biased. Some points related to the interpretation of the findings warrant discussion, however. Mortality maps are likely to be influenced by "noise" due to variability in the figures, and this is particularly true in areas with small and unevenly distributed populations and when the number of cases is small (Clayton and Bernardinelli, 1992). This also applies in the present instance on account of the relatively small population and the small size of the cells. More stable results could have been obtained by using larger aggregation units, at the cost of obscuring potentially important information (Wittie et al., 1996). Despite some random variation, certain SMRs proved to be significantly high or low and also showed some spatial accumulation, especially in the male sex.

Mobility within the population gives rise to obvious difficulties in assessing variations in deaths within a city. Movements of people, migration, commuting and other mobility occurring over the long period of time between birth and death have an influence on the death rates in an area (Schaerström, 1996). In the case of Oulu the population at risk is highly affected by inter-regional migration and movements within the city. The residential areas and the areas where most of the work places are located have become more differentiated, and commuting between home and work places has increased. Mortality in a given cell is therefore an indicator of living conditions among the residents in more general terms, not a direct measure of local exposure. The effects of population movements, mainly health-based selection, cannot be measured in any straightforward way and it is therefore difficult to achieve an explanation for small-area variations in mortality. In addition, cell-specific mortality figures are not based on any actual cohorts of individuals but rely on the assumption that age-specific mortalities in each cell in 1978–1995 remain unchanged during the whole lifetime of the people living there. Thus, relevant exposures experienced previously may not be correctly linked with the actual place of death. Selective migration in particular is likely to increase or reduce death rates in certain areas. Mortality data usually contain only information on the place of residence, but in many cases information on the place of work would be more necessary.

In any case, the assignment of place of residence for an individual is not unambiguous. People dying in institutions may be allocated to the area of the institution rather than the area in which they resided before being institutionalized. In theory, allocation failures of this kind may artificially increase or reduce
mortality in some cells. In Finland, the place of residence of persons dying in institutions is usually not coded at all but practices have not been uniform and biases cannot be totally excluded.

Although some areas were found within the city where high mortality was sustained over the period studied, the overall impression was that of a changing pattern, which is partly due to random variation but may also reflect the influence of the rapidly changing urban structure and consequent health effects based on selection, lifestyles, work exposures and deprivation. In particular, the areas of persistently high mortality may point to an ongoing polarization, the deleterious health effects of which should be examined using more detailed surveys.

6. Uncited References


References


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